1) Project Information

A GOES Thermal-Based Drought Early Warning Index for NIDIS

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First Progress Report for the period of 1 June 2009 – 31 March 2010

1) Results and Accomplishments

The objective of this project is to produce satellite-based maps of evapotranspiration (ET) and soil moisture (SM)-related drought indices over North America in direct support of the NCEP/CPC North American Drought Briefing (NADB) and the National Integrated Drought Information System (NIDIS). Products will be delivered in near real-time directly to NCEP/CPC and distributed publically through the NIDIS U.S. Drought Portal. The remote sensing products will be generated by a regional-scale Atmosphere-Land Exchange Inverse (ALEXI) model, which diagnoses the surface energy balance using a time-differential land-surface temperature rise signal derived from GOES thermal imagery. The ALEXI-based Evaporative Stress Index (ESI), representing standardized anomalies in the ratio of actual to potential ET (f_{PET}), shows good spatiotemporal correspondence with standard precipitation-based drought indices. In this work, we are developing a suite of ALEXI drought products on a $1/8^{o}$ grid over the contiguous U.S. (CONUS), Canada, and Mexico, with the intent of transition to operations within NESDIS/NCEP by the project's end.

In Year 1 of this project, the primary implementation tasks were to a) port the ALEXI processing infrastructure, currently running at University of Alabama-Huntsville (ALEXI-UAH), to machines at NESDIS, integrating standard NOAA input products (ALEXI-NOAA); and b) conduct an intercomparison of the existing 10-year ALEXI-UAH ESI archive with standard drought indices used in the USDM and NADB, and with the USDM itself.

Porting ALEXI infrastructure to NESDIS (ALEXI-NOAA) and archive generation

The current manager of the ALEXI-UAH system (Christopher Hain) was hired by NESDIS to implement porting of ALEXI to NESDIS and oversee construction of an ALEXI-NOAA ET drought product archive back to 2000. The retrospective archive is critical for real-time drought monitoring, which is typically based on moisture anomalies with respect to long-term normal conditions.

Hourly skin temperature and insolation are being obtained from the NESDIS GOES Surface and Insolation Product (GSIP). GSIP products for 2008-2009 have been retrieved, with real-time archival of 2010 ongoing. Collocation algorithms have been developed to interpolate GSIP land

surface temperature and surface insolation fields to the North American ALEXI domain, and all 2008 and 2009 GSIP land surface temperature and surface insolation fields have been processed with the collocation algorithm. NESDIS is planning to reprocess GOES data to meet the long-term GSIP archive data need.

Meteorological inputs to ALEXI (primarily wind speed and lapse rate) are being extracted from the Regional Climate Data Assimilation System (R-CDAS) – the real-time continuation of the North American Regional Reanalysis (NARR) performed by the NCEP Environmental Modeling Center (EMC). NARR fields for 2000-2005 and 2008-2009 have been extracted and archived. A new pre-processing system has been developed to ingest NARR meteorological fields needed by ALEXI (e.g. profiles of potential temperature and vapor pressure). This automated system is currently undergoing testing, and full NARR retrieval and ALEXI-NOAA archive generation will commence in the next few months.

A consistent 2000-present archive of ALEXI products will be delivered to CPC by end of year 2 so that Dr. Mo can begin web testing and integration into the NADB.

Drought index intercomparison using ALEXI-UAH product archive

Dr. Agustin Pimstein was hired by USDA-ARS to oversee intercomparison efforts. These intercomparisons will provide NCEP/CPC with detailed information about how ESI behavior (temporal and spatial response to drought events) compares to that of standard drought indices currently used in the NADB. Contextual understanding of this sort is critical before new indices can be effectively integrated into any operational drought monitoring effort.

Prior to availability of the full ALEXI-NOAA product archive, drought index intercomparisons are being conducted with the existing ALEXI-UAH archive (2000-present). A rigorous cross-comparison of ALEXI-NOAA and ALEXI-UAH will be conducted for when the new dataset comes on line to ensure consistency.

First, the existing ALEXI-UAH archive was extended from growing season (April-September) coverage to include the winter months (full year coverage). This involved retrieving GOES-E and -W thermal and shortwave data (the latter used in generating insolation fields), generating requisite surface and atmospheric meteorological data fields with MM5, and creating CONUS-wide mosaics of the MODIS leaf area index (LAI) product. In the process, several refinements to the ALEXI-UAH system were implemented (e.g. snow masking; noise reduction in insolation fields; post-processing cloud removal).

An intercomparison was conducted between the ESI, standard precipitation-based indices (SPI, PDSI, PHDI, Z, PMDI) and drought classifications reported in the U.S. Drought Monitor during 2000-2009. Spatial distributions in ESI were found to correlate well with patterns in the precipitation-based indices, responding to rainfall events at monthly timesteps (Figs. 1 and 2). Another advantage identified in the ESI technique is that the thermal remote sensing picks up signatures of moisture inputs that are not collocated with precipitation events (irrigation, wicking from shallow water tables, etc), which may mitigate effects of local rainfall deficits. These additional moisture sources will not be represented in prognostic land-surface models like NLDAS without prior knowledge of their existence. We find better agreement between

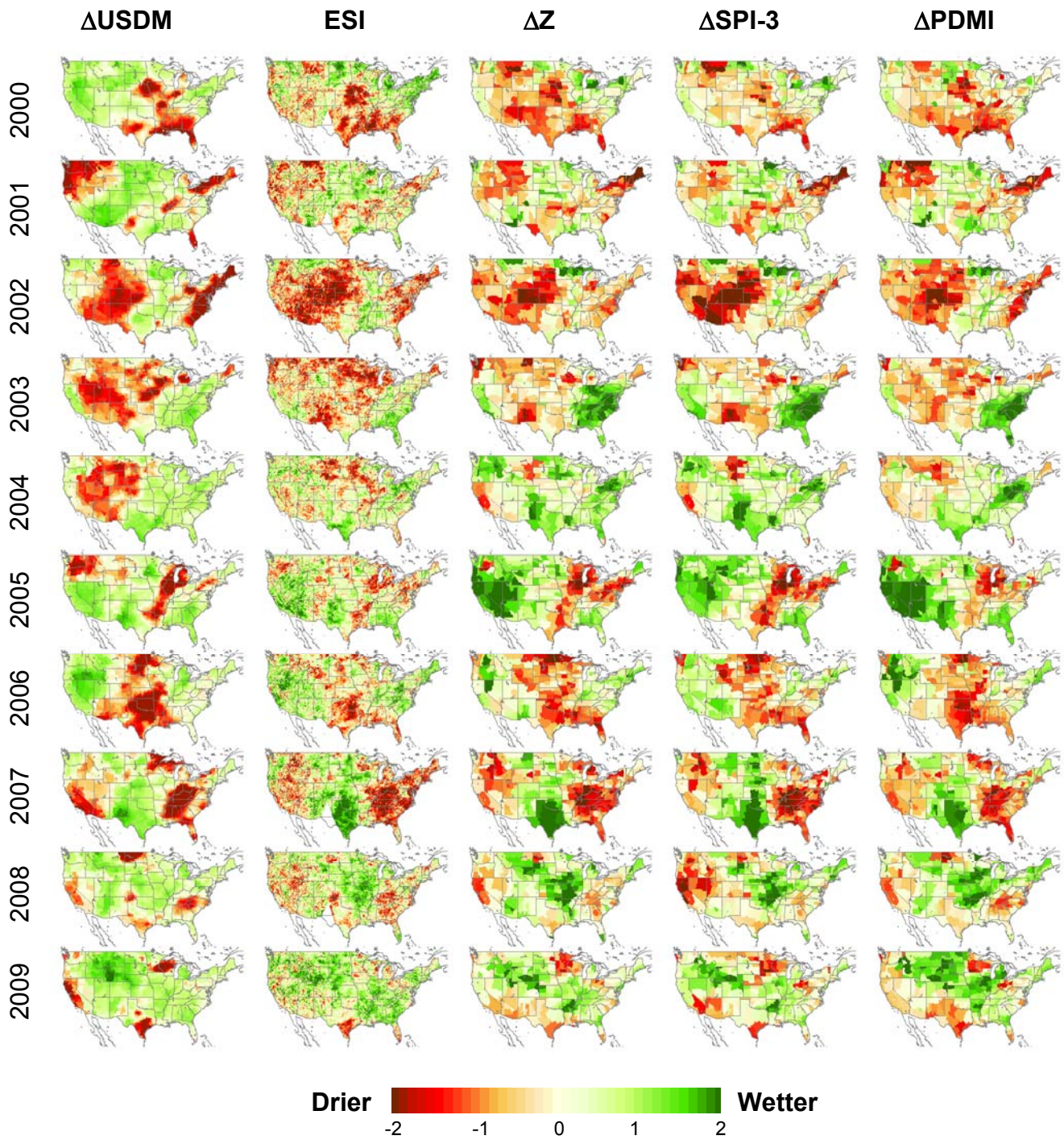

Figure 1: Seasonal (26-week) anomalies in USDM, ESI, Z, SPI-3, and PDMI for 2000-2009.

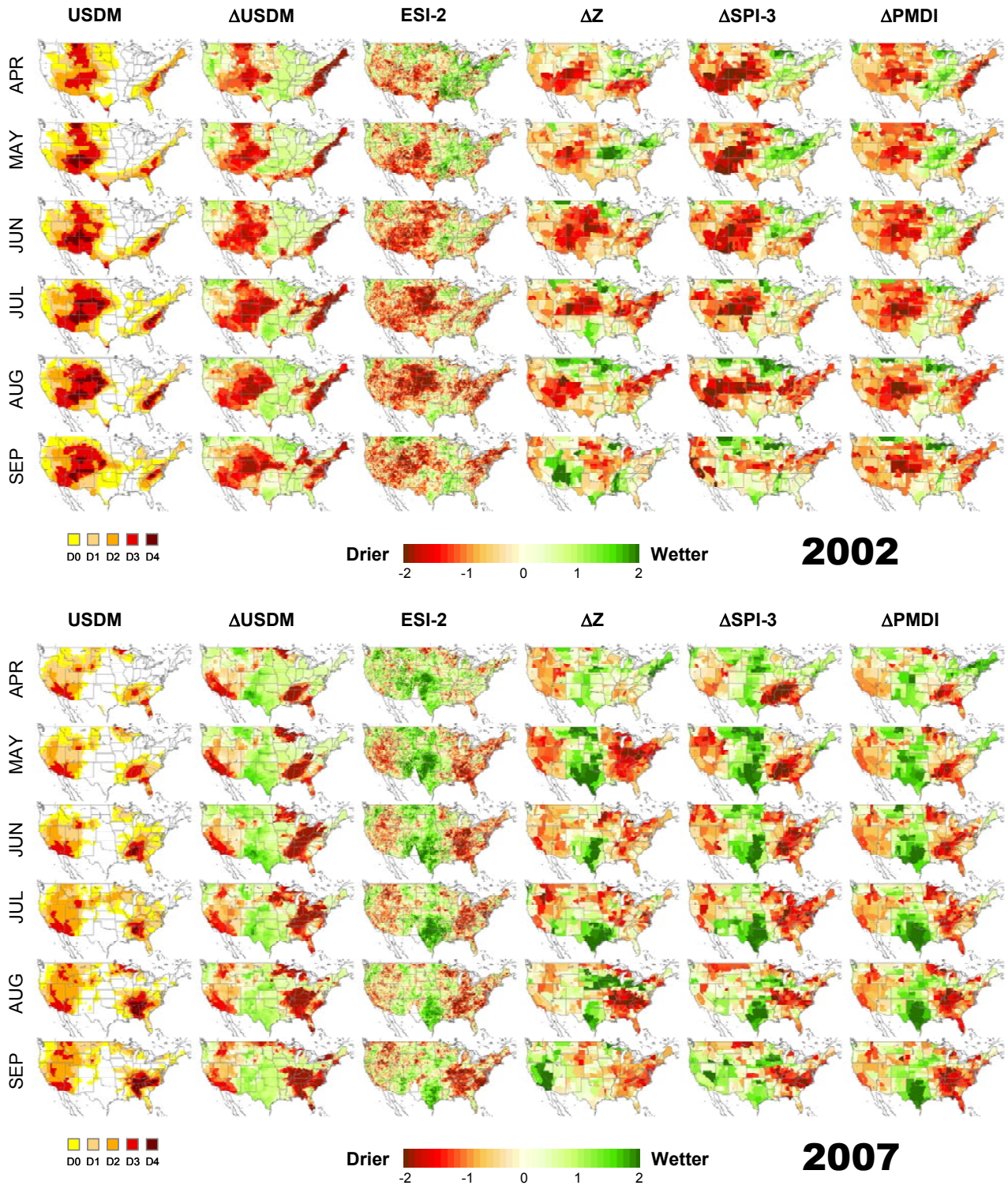

Figure 2: Monthly standardized anomalies in the USDM drought classes (ΔUSDM), the 2-month ESI composite (ESI-2), the Palmer Z index (ΔZ), the 3-month Standardized Precipitation Index (ΔSPI-3) and the Palmer Modified Drought Index (ΔPMDI) for 2002 and 2007. Also shown are USDM drought classes for the week closest to the end of each month (first column).

anomalies in f_{PET} (ET/PET) and standard drought indicators than we do for anomalies in ET itself, suggesting that normalization by PET serves to isolate the ET signal component due to soil moisture variability from that due to radiation load.

Dr. Pimstein is expanding the intercomparison to include the Vegetation Health Index (VHI) and other precipitation products used in the NADB. He is working with Dr. Kingtse Mo and the NOAA NLDAS team to obtain a retrospective archive of NLDAS drought indices for comparison.

2) Highlights of Accomplishments

- Commenced retrieval of archived GSIP and NARR data fields for retrospective model runs.
- Instituted automated capture of real time GSIP and R-CDAS fields for real-time model runs.
- Developed new preprocessing infrastructure to ingest GSIP radiation fields and NARR meteorological input to ALEXI.
- Conducted 10-year quantitative intercomparison of existing ESI archive with standard precipitation-based drought indices (SPI, PDSI, PHDI, Z, PMDI) and USDM drought classifications.
- Currently extending intercomparison to include VHI and NLDAS drought products (soil moisture, evapotranspiration, runoff).

3) Publications

Anderson, M. C., C. R. Hain, B. Wardlow, A. Pimstein, J. R. Mecikalski, and W. P. Kustas, 2010: Evaluation of a drought index based on thermal remote sensing of evapotranspiration over the continental U.S. *J. Climate*. In review.

Anderson, M. C., C. R. Hain, B. Wardlow, A. Pimstein, J. R. Mecikalski, and W. P. Kustas, 2010: A drought index based on thermal remote sensing of evapotranspiration. In *Remote Sensing of Drought*, B. Wardlow, M. C. Anderson, and J. Verdin, Eds., Taylor and Francis. In preparation.

4) PI Contact Information

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